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Semicoa JANS2N2907AUB Total Ionizing Dose Test Report

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1. Introduction

This test serves as the radiation lot acceptance test (RLAT) for the Semicoa JANS2N2907AUB date codes specified. During testing, the device was exposed to low dose rate (LDR) gamma irradiation at a dose rate of 10 mrad(Si)/s. Datasheet parameters were characterized over dose, with an emphasis on gain degradation, and data are presented at 0 krad and 30 krad within.

2. Devices Tested

2.1. Part Background

The JANS2N2907AUB is a space-grade PNP transistor qualified to MIL-PRF-19500/291W and sold with no radiation hardness assurance level, though the manufacturer offers higher levels of RHA as an option. AUB suffix indicates a 3-pin surface mount package.

2.2. Device Under Test (DUT) Information

A total of 88 parts over 4 batches were provided for testing in groups of 22. All specifications and descriptions are according to MIL-PRF-19500/291W. More information can be found in Table 1.

Table 1. Part Identification Information

Part Number	JANS2N2907AUB
Manufacturer	SEMICOA
Lot Date Code	2026, 2012A, 2028, 1921
REAG ID	21-005, 006, 007, 008
Quantity Tested	80 + 8 controls
Part Function	PNP small signal transistor
Part Technology	Bipolar junction transistor
Package	3-pin surface mount (AUB)

3. TEST SETUP

General test procedures were in accordance with MIL-STD-883, Method 1019, Condition D. Parts were serialized randomly. ESD procedures were followed during test and transfer of the devices between irradiation chamber and characterization. Exposures were performed at ambient laboratory temperature.

Measurements were performed with Keithley 2400 source-measurement units and Keithley 4200 semiconductor characterization system in the GSFC Code 561 laboratories. Data was collected with LabVIEW and tabulated in Microsoft Excel.

4. TEST DESCRIPTION

4.1 Irradiation Conditions

Radiation testing was performed with gamma radiation at 10 mrad(Si)/s. Eighty (80) parts were irradiated with 8 reserved as controls, divided among four lot date codes. Half the irradiated parts from each group were exposed in a biased configuration and half were grounded. Prior to the first radiation dose, all 88 parts were electrically tested. After each exposure level, the parts were tested again and returned to radiation within the time limits defined by MIL-STD-883, Method 1019. See Table 2 for more information.

Parts indicated as "biased" were irradiated with V_{CE} = -35 V. Parts indicated unbiased had all terminals shorted together and tied to an external ground potential.

Table 2. Device Grouping

Group	LDC	Qty	Bias	Dose Rate	Exposure Level Steps (krad(Si))
1	2026	10	*Unbiased*	*10 mrad/s*	*0, 30*
2	2026	10	*Biased*	*10 mrad/s*	*0, 30*
3	2026	2	*Control*		
4	2012A	10	*Unbiased*	*10 mrad/s*	*0, 30*
5	2012A	10	*Biased*	*10 mrad/s*	*0, 30*
6	2012A	2	*Control*		
7	2028	10	*Unbiased*	*10 mrad/s*	*0, 30*
8	2028	10	*Biased*	*10 mrad/s*	*0, 30*
9	2028	2	*Control*		
10	1921	10	*Unbiased*	*10 mrad/s*	*0, 30*
11	1921	10	*Biased*	*10 mrad/s*	*0, 30*
12	1921	2	*Control*		

4.2 Electrical Tests

Specification thresholds were set in accordance with MIL-PRF-19500/291W. Where noted by (RHA), specifications are the post-radiation limits provided in MIL-PRF-19500/291W. For the application intended, the selection of these JANS parts with in-house RLAT was an alternative to procurement of JANSR parts. Therefore, parts were tested against the relaxed post-radiation limits of the JANSR parts and not to the pre-irradiation limits provided for the JANS device procured.

All data from the electrical tests in Table 3 were logged in excel spreadsheet files.

Table 3. List of Electrical Tests Performed

Symbol	Parameter	MIN	TYP	MAX	Units	Test Conditions
$V_{(BR)CEO}$	Emitter-Collector Breakdown Voltage	60			V	I_C = 10mA
$I_{CBO,1}$	Collector-Base Cutoff Current			10	uA	V_{CB} = 60 V
$I_{CBO,2}$	Collector-Base Cutoff Current			10	nA	V_{CB} = 50 V
I_{CES}	Collector-Emitter Cutoff Current			50	nA	V_{CE} = 50 V
$I_{EBO,1}$	Emitter-Base Cutoff Current			10	uA	V_{EB} = 5 V
$I_{EBO,2}$	Emitter-Base Cutoff Current			50	nA	V_{EB} = 4 V
h_{FE1}	DC Current Gain (RHA)	37.5				I_C = 0.1 mA, V_{CE} = 10 V
h_{FE2}	DC Current Gain (RHA)	50		450		I_C = 1.0 mA, V_{CE} = 10 V
h_{FE3}	DC Current Gain (RHA)	50				I_C = 10 mA, V_{CE} = 10 V
h_{FE4}	DC Current Gain (RHA)	50		300		I_C = 150 mA, V_{CE} = 10 V
$V_{BE(SAT),1}$	Base-Emitter Saturation Voltage	-0.6		-1.3	V	I_C = 150 mA, I_B = 15 mA
$V_{BE(SAT),2}$	Base-Emitter Saturation Voltage			-2.6	V	I_C = 500 mA, I_B = 50 mA
$V_{CE(SAT),1}$	Collector-Emitter Saturation Voltage			-0.4	V	I_C = 150 mA, I_B = 15 mA
$V_{CE(SAT),2}$	Collector-Emitter Saturation Voltage			-1.6	V	I_C = 500 mA, I_B = 50 mA

6. Source Requirements

The total dose source is in a room air source gamma ray facility, which is compliant with MIL-STD-883, Method 1019. Dosimetry is NIST traceable.

7. Results

	Average of all irradiated lots		99/90 statistical range after 30 krad(Si)		Comments
Parameter	0 krad (Si)	30 krad (Si)	Low Bound	High Bound	
$V_{(BR)CEO}$	> 60 V	> 60 V	n/a	n/a	All parts within spec
$I_{CBO,1}$	-0.201 nA	-0.664 nA	-1.75 nA	+0.425 nA	All parts within spec
$I_{CBO,2}$	-0.609 nA	-1.05 nA	-2.74 nA	+0.634 nA	All parts within spec
I_{CES}	-0.239 nA	-0.825 nA	-1.21 nA	-0.438 nA	All parts within spec
$I_{EBO,1}$	0.553 nA	0.960 nA	0.204 nA	1.72 nA	All parts within spec
$I_{EBO,2}$	0.331 nA	0.529 nA	0.018 nA	1.04 nA	All parts within spec
h_{FE1}	196	64	46.2	80.9	All parts within spec
h_{FE2}	212	98	84.4	112.0	All parts within spec
h_{FE3}	220	121	93.4	148.2	All parts within spec
h_{FE4}	258	159	80.2	237.6	All parts within spec
$V_{BE(SAT),1}$	-0.868 V	-0.860 V	-0.959 V	-0.760 V	All parts within spec
$V_{BE(SAT),2}$	-1.008 V	-0.988 V	-1.08 V	-0.897 V	All parts within spec
$V_{CE(SAT),1}$	-0.224 V	-0.246 V	-0.332 V	-0.159 V	All parts within spec
$V_{CE(SAT),2}$	-0.685 V	-0.799 V	-1.01 V	-0.587 V	All parts within spec

8. Summary

All parameters met specification limits for the JANS2N2907AUB after 30 krad(Si) of low-dose rate gamma irradiation, with the exception of the DC current gain values which are tested against the post-radiation limits provided for JANSR2N2907AUB. Statistical bounds are presented to guide appropriate usage of the parts in the 30-krad application.

9. References

1) Department of Defense "Test Method Standard Microcircuits," MIL-STD-883 Test Method 1019.9 Ionizing radiation (total dose) test procedure, June 7, 2013, https://landandmaritimeapps.dla.mil/Downloads/MilSpec/Docs/MIL-STD-883/std883.pdf.
2) MIL-PRF-19500/291W, effective 17 May 2016.